# Developing your Web presence

The exercise of power is determined by thousands of interactions between the world of the powerful and that of the powerless, all the more so because these worlds are never divided by a sharp line: everyone has a small part of himself in both - Vaclav Havel

WEDNESDAY, MAY 23, 2007

## A Coffee Can Foundry... (making bronze, part 1)

As a chemist I've always wondered how early humans, without any knowledge of modern Chemistry, managed to make metals as versatile as bronze and iron. Although these discoveries have been understood for quite a while now, it remains to me quite amazing that the earliest tin bronze has been dated back as far as the late 4th millennium BC!

And so I decided to go on a bit of an "*amateur chemico-archaeological dig*", to find out how hard or easy it is to make bronze, armed with sound knowledge of the chemistry involved but only equipped with a *kitchen laboratory* (much to my wife's perennial chagrin). This is the first instalment of this little (?) journey...

I will not bore my readers with much chemical jargon or chemical formulas. The relevant details can very easily be found on t'Interwebs anyway. It suffices to know and understand *three rather simple notions:*

1. Traditional bronze is an alloy of copper and tin, in varying ratios, depending on desired properties of the alloy.

2. Copper can be made by chemical reduction of its oxide (copper oxide) to the elemental copper metal, using carbon (charcoal or cokes) as a reducing agent. The carbon "burns" off as carbon dioxide, leaving the metal behind. This reaction requires considerable heat to get started.

3. Tin can be made by chemical reduction of its oxide (tin dioxide) to the elemental tin metal, using carbon (charcoal or cokes) as a reducing agent. The carbon "burns" off as carbon dioxide, leaving the metal behind. This reaction requires considerable heat to get started.

The operative word here is definitely *heat*, read *furnace*. As the early bronze makers didn't have natural gas, propane or butane at their disposal, their furnaces would have been charcoal or wood-fired. And so the starting point

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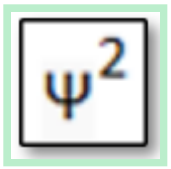


**Name:** Gert
**Location:** Yorkshire, United Kingdom

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of my journey became the design and construction of a small, simple and inexpensive charcoal-fired furnace.

After a bit of surfing I came across a very simple but rather perishable design for a so-called Coffee Can Foundry, here and its more robust follow-up, CCF Mark II, here. I decided to go for design II, using a 2.5 l empty paint can.

Simply put, the construction involves casting a cheap refractory material which is essentially a composite of Perlite (volcanic ash and also a common gardening material) and common fire cement, into a home-made mould. I used my paint can as the outside and an empty squash bottle as the inside of the mould. The rest involved some drying and baking (while the wife wasn't in sight) in our kitchen oven. Here are some pictures of my creation, shortly after the first tests today:

Before attempting to reduce the metal oxides, I needed to run some tests and get a bit of experience with this primitive piece of kit. One good way of getting to know the *Paint Can Foundry*, is to attempt to melt aluminium. Aluminium is readily available in the form of empty beer or pop cans and has a melting point of 660 degrees centigrade (DC). So, basically, if your foundry can melt aluminium, then at it has least reached that temperature.

My first attempt at getting a fire going involved a hairdryer and ended up with... *no fire and a hairdryer, battered, broken and in the bin*. Needless to say, the ancient furnaces would probably have been fanned by means of bellows (possibly powered by water, wind, animals or slaves).

So instead I got myself a second hand Hoover, more or less dismantled it to get access to the airflow (previously to the now defunct bag) and started the first serious trials.

The vac now blows into a cardboard funnel at the end of the tuyère (air inlet, in foundry jargon) and I can regulate the flow by increasing/decreasing the distance between the funnel and the (very strong) airflow from the vac.

It didn't seem to bode very well at first with having difficulty getting the charcoal to light, using methanol. But I kind of got the hang of it after a bit.

Eventually, after some mucking about, I got the fire to burn a bright amber-red (about 800 DC, at a guess). The first attempt at melting some aluminium can material failed because it *turned out to be a steel can!*

The second attempt also failed, using some aluminium from a coke can.

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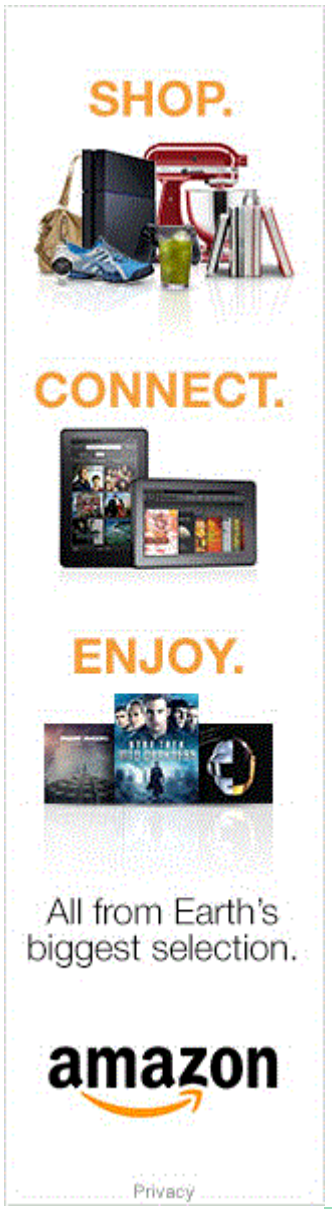

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Even the third attempt, using household aluminium foil, failed. Then I decided to try and put the lid of the paint can on the furnace and bingo, *the foil melted alright!* I added some coke can aluminium and that started to melt too but by then the charcoal had burnt out. So I definitely got past the 660 DC mark... Some more tests with smaller, cut up pieces of can material, rather than the quite large chunks I'd been using so far, were also successful but excessive *dross* from the paint and various can coatings didn't really yield anything castable, so *no aluminium ingots today.*

The main problem remains getting the airflow right. The other problem is that the charcoal really burns fast and the charge (about a good handful) burns out in about 5 minutes. Recharging is possible but doesn't really solve much because by the time I've got a good glow going again, the crucible (well, a fashioned *steel can*, actually...) has then cooled down almost completely. *Propane, here I come, I guess.* The foundry was actually designed with a propane burner (to be inserted through the tuyère) in mind, should later I want to experiment further.

I'll probably have to fool around a bit with the size of the charcoal chunks too...

Nonetheless, with some practice I feel it should be possible to run the copper oxide and tin dioxide reductions with charcoal without too many problems *(famous last words!)* The furnace might not reach the 1084 DC required to melt copper (or keep it molten) but the reaction enthalpy (heat released during the reaction) should help. Tin melts at 232 DC only, so no problem there.

The furnace itself held up very well though: no discernable cracks, just a little shrinkage, probably due to driving off some moisture.

Next time I'll try and cast some aluminium and melt some copper coins. *Questions in the comment section, please...*

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**Update:**

Pictures of the operating furnace and the results of the first melts can be found in this post.

posted by Gert @ 3:10 PM 4 comments

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SUNDAY, JUNE 17, 2007

## A Coffee Can Foundry... (making bronze, part 5)

*This is Part 5 of my mini-saga on attempting to make home-made bronze, using a method similar to Bronze Age technology. Parts 1, 2, 3 and 4 can be found here:*

Part 1: Goal, building and initial tests
Part 2: First attempts at metal melting


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Part 3: Improving the foundry
Part 4: Lump charcoal is as lump charcoal does...

**Summarising the goal of the project...**

I'm now close to achieving the stated goal of the project and it's worth summarising what the object of this little adventure is. Basically I'm trying to produce small amounts of castable bell bronze (20 - 25 w% tin) using a method close to what our Bronze Age ancestors would have used in all likelihood, although they would have done this on a large scale. Bronze is an alloy of copper and tin and both metals can be obtained by reducing their oxides by means of a chemical reduction with carbon. The oxides occur readily in nature as ores, in the case of tin a mineral called Cassiterite and in the case of copper, Cuprite (for both metals also other ores are also available). Cassiterite is mainly tin oxide, with small amounts of iron oxide as a contamination, while Cuprite is mainly copper (I) oxide. Carbon is of course most commonly used in the form of coal or charcoal.

By glowing the oxides with the right amount of carbon, the carbon recombines chemically with the oxygen present in the oxide, thereby being carried off as carbon dioxide and leaving the "pure" metals behind. I say "pure" because this is a technical process and the metals are therefore always slightly contaminated.

The process of extracting metals from their oxides by means of heat and a reducing agent (beside carbon there are many others such as aluminium, magnesium, calcium, lithium and others) is known as pyrometallurgy and our Bronze Age (and Iron Age) ancestors were master pyrometallurgists. We still are today, even more so...

My objective is to carry out both reductions at the same time on an appropriate mix of Cassiterite and Cuprite. Both constituent components of bronze would then form at the same time, fuse together and bronze metal would be the result.

**The Cassiterite reduction**

Cassiterite, a mineral once found and mined in abundance in Cornwall, South England, is a little hard to come by today, especially in small amounts. Instead I'm using the purer yet cheaper form which is essentially technically pure tin oxide ($SnO_2$). This is an off-white powder with a slightly greenish hue. It contains about 79 w% of tin metal.

Mixed with the theoretical, chemically required amount of carbon (I used the same charcoal that I use as fuel for the charcoal-fired paint can foundry but added some 20% extra to the mix to account for some that would simply burn off at these temperatures) and glowed to about 900 C (1650 F) or higher, the reduction reaction proceeded fast and easily.

It's interesting to watch, as the liberated by-product (carbon dioxide) puffs up the hot, powdered mix a little, then proceeds actually to bubble out of the mix. The powder is behaving therefore much like a boiling liquid that reduces steadily in volume, until only a small puddle of molten tin metal remains (MP 232 C/450 F). It's perfectly possible to keep topping the

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crucible with fresh "Cassiterite"/charcoal mixture, which then continuously reduces to pure tin metal, thereby filling up the crucible with the desired metal. The crucible in question here was a stainless steel former sugar bowl...

During the early stages of the reaction, the mixture darkens somewhat, probably due to the formation of finely divided tin metal, bubbles of carbon dioxide start to form and then small pearls of tin metal start appearing, which then later settle at the bottom of the crucible as a puddle of molten metal.

The "pearling effect" is apparently something that can be witnessed by putting some Cassiterite (you can find it in small quantities in mineral shops or around the now mostly abandoned Cassiterite mines in Cornwall) on the fire of a hot charcoal fired barbecue: the combination of heat and carbon causes some of the Cassiterite to reduce to tin metal. This is one of the most likely routes of discovery of this useful metal by our ancestors...

Right, two tin buttons (29 g) made by reducing tin oxide, left a copper blob (13 g) made by reducing copper (I) oxide. The copper is porous and "bubbly", probably because carbon dioxide got trapped during solidification. The white spot on the copper is a shard of porcelain from the broken crucible.

**The Cuprite reduction**

For basically the same reasons as above, I substituted the Cuprite ore with technically pure copper (I) oxide ($Cu_2O$), which is a heavy, wine-red powder. It contains about 89 w% of copper metal.

Other copper ores contain significant quantities of iron and sulphur and it's much harder to pyrometalurgically extract the metal from these. It is reasonable to assume that our ancestors did eventually master the art of extracting copper from the more unyielding ores but that they preferred (and started out with) the copper (I) oxide based ores, like Cuprite. Even today, I bet Cuprite ore still fetches a better market price than the other ores, because of its ease of conversion to the desired metal...

Mixing the "Cuprite" with charcoal and glowed along the same lines as above, this reaction proceeds also steadily although it all looks quite differently. The mixture starts darkening and glowing very quickly with the occasional green flame (typical of copper) erupting. At first I thought that the copper (I) oxide ($Cu_2O$) was merely oxidising further to copper (II)

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oxide (CuO is black) but at the end of the test I prised open the contents of the cooled crucible (breaking it in the process!) pure, slightly spongy and porous copper metal was clearly there. A quick estimate based on the weight of the crucible and its contents before and after firing seemed to indicate that the reaction copper (I) oxide + carbon --> copper metal + carbon dioxide had proceeded stoichiometrically. That requires some corroboration though: it's possible that some oxidation of the copper (I) oxide to copper (II) oxide did indeed take place and that not quite enough carbon was present to reduce the copper (II) oxide to copper metal...

Although the metal almost certainly formed in the liquid state, I didn't manage to keep it molten: copper's melting point is 1084 C (1984 F) and although I've melted both brass and copper in my dinky toy furnace before, it requires maximum running temperatures to achieve that. I may have been slightly short of that and it was only the very first test, cut slightly short because it started raining...

The paint can furnace during firing...

So, on the Cuprite side of things some problems remain to be resolved. The main problem is to achieve the high temperature needed to keep the copper metal molten and that entails a highly temperature resistant crucible. On this first test I used a 60ml chemlab ceramic crucible. Whilst this definitely resists that kind of temperatures (and higher), the material is also very fragile (hence the breakage when prizing the metal out) and not really suitable for this kind of thing. Some reading and some advice by the foundry enthusiasts at the ABYMC forum would indicate that in all likelihood a clay-graphite crucible is in order for more experimentation. This is definitely the material of choice for bronze temperatures. Steel can survive these temps as well, but copper is said to dissolve some chemical components of steel, making the material vulnerable in this usage.

Next stop: actually making bronze metal or so I hope...

**Anticipation: three roads to bronze...**

It's possible to envisage four possible routes to bronze, during the Bronze Age:

1. Two reductions and one alloying smelt:

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This route would involve running the Cassiterite and Cuprite reductions separately, resulting in ingots of both tin and copper metal. Melting these together would yield the desired bronze alloy. This would require three furnace firings.

2. Two reductions, one of them being also an alloying smelt:

This would involve making either copper or tin, then loading some of either metal into a reducing crucible and adding the reducing mix for the other metal. The pre-loaded metal and the newly formed metal would then result in bronze. This would require two furnace firings.

The reduction of copper oxide in the presence of the right amount of tin metal would appear to be the most attractive here because of the lower melting point of tin.

3. Two reductions carried out simultaneously:

By reducing a mix of Cassiterite and Cuprite (mixed in the correct ratio) a bronze alloy could be obtained using one firing only. It's my contention that that is possible and that our ancestors would have cottoned onto that too. Wait and see...

posted by Gert @ 2:23 PM

8 comments

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THURSDAY, MAY 24, 2007

## A Coffee Can Foundry... (making bronze, part 2)

**In this previous post I outlined a plan to make home-made bronze, using a so-called coffee can foundry**. Here I'll show the first results of some aluminium and copper melting attempts.

I switched to barbecue briquettes instead of simple charcoal, more by accident than by design (wrong purchase!), but it worked out rather well. The briquettes are higher in density and pack more carbon (the fuel!) than ordinary charcoal per unit of volume. Broken up into roughly 1 cm pieces and used as previously, the burning rate and furnace heat seemed comparable but burning time appeared more than doubled.

**Here's the furnace during firing:**

**The first aluminium mini-ingot:**

**Another aluminium ingot:**

The top ingot weighs 6.5 g and was obtained from 14.2 g of aluminium take-away food trays.

While in the previous post I suggested cutting up the aluminium material into small pieces, on second thought this was *really not the way to go*. It's better to hammer the material into a tight and compact chunk, preferably one that fits the crucible snugly. This way heat will be transferred to the metal quickly (thereby saving time). Metals are excellent heat conductors (aluminium is almost "best in class" on that point) and the chunk will quickly heat throughout. Smaller pieces separated by air will take a little longer to heat through due to the insulation provided by the air. Higher surface area will also lead to more oxidation of the aluminium (see below), leading to more dross. The ingots above were both obtained from compact chunks of aluminium material. The molten aluminium was "cast" simply onto dry beach sand.

The bottom one (here compared to a 2 pence coin) weighed 22 g and came from 24 g of similar material.

The loss is mainly due to the formation of *dross*, in the case of "clean"

(uncoated or unpainted) aluminium from passivation. The surface of the hot aluminium reacts with oxygen and forms aluminium oxide, which creates a skin on the melt, *very similar to the skin often found on boiled milk*. It makes casting rather difficult and can only be removed from larger melts by *skimming the dross off*. But casting metals isn't really my priority right now...

At the end of the melt and cast that yielded the second ingot, the furnace was still going strong and I added a few brass (97 w% of copper) coins (checked with a magnet: some "copper" coins are actually copper coated steel) and reinserted the crucible. The coins heated up to a dull red glow but *didn't melt*. Unfortunately they weren't given much time as the inevitable happened: the thin-walled steel can crucible finally burned through. Having withstood 5 or 6 intense onslaughts of heat and air, it's rather a surprise it lasted that long; the steel had been literally burning away slowly, forming *iron oxide* (better known as *rust*).

*So, on whether the furnace reaches the required 1084 DC to melt copper, the jury is still out...*

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**Update:**

Based on the fact that the furnace burns about 90 g of carbon (3 charcoal briquettes) in 10 minutes, the power generated is about *5 kW (5,000 W)*, or five times the power of a high range domestic microwave oven. Not bad for such a dingy construction!

But that doesn't solve the copper melting problem. To better establish the temperature obtained in the crucible, I decided to try and melt some ordinary kitchen salt (chemically: sodium chloride) which has a *melting point of 801 DC*. I charged the (new) crucible with 30 g of salt and fired up the furnace. The salt melted but only just, see photo below:

A small chunk of salt remained solid (not molten), indicating the

temperature inside the crucible must have been very close to the melting point of the salt. The salt proved uncastable as it re-solidified immediately after removing the crucible from the heat. I later prized the salt out of the crucible and it showed a clear imprint from the crucible bottom. A piece of re-solidified salt (blackened by the burning can-coating) can be seen on the right side of the picture below:

So, the good news is that my initial estimate (based on glow colour) of 800 DC was pretty accurate but the bad news is that that is *about 200 DC short of the meting points of copper, brass and bronze!* To increase the temperature as much as possible I will now try two approaches combined:

1. Using a tightly fitting lid made of the proven Perlite/fire cement refractory material, to prevent heat loss through convection and radiation.

2. Prolonged firing of the furnace by means of "in-flight refuelling". By adding about 1 1/2 briquette to the fire about every 5 minutes, it should be possible to fire the furnace almost continuously, thereby reaching a higher equilibrium temperature than obtained so far.

Although the object of these experiments isn't really to cast metals, I kind of got the taste of it and I like it. So I decided to make another ingot, somewhat larger and cast into an actual mould (an inverted *corned beef tin*), using the mixed aluminium material (45 g) shown in the middle of the picture above (left is some lead metal from car wheels, for a later melt).

Again, the *dross* played up and casting was difficult: the resulting ingot can be seen below. The dross simply dropped out of the crucible and onto the casting! It's clear that to melt aluminium waste (coated and painted) that generates considerable amounts of dross, it's necessary to have a bath of at least *100 - 150 g of "clean" aluminium melt*, into which the waste can then be dropped. The waste should melt quickly (a bit like dropping ice cubes into hot water) and that removing the dross by skimming should then be easier. *But for this continuous operation of the furnace is a must...*

**Here's the third instalment on work on the foundry**

posted by Gert @ 7:45 PM

3 comments

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SATURDAY, JUNE 02, 2007

## A Coffee Can Foundry... (making bronze, part 3)

*This is Part 3 of my mini-saga on attempting to make home-made bronze, using a method similar to Bronze Age technology. Parts 1 and 2 can be found here:*

Part 1: Goal, building and initial tests

Part 2: First attempts at metal melting

**Improving the foundry**

The main purpose of a foundry furnace is of course to reach the temperature needed to melt the metal or alloy in question. In part 2 I showed that the coffee can foundry (well, paint can foundry) was unable to melt copper (coins).

And so I set out to improving the thermal performance of the furnace by means of the following modifications:

1. Use a Perlite/fire cement refractory lid to bounce some of the radiation loss back into the furnace.
2. Start to fire the furnace in a semi-continuous way, by adding charcoal every 3 - 5 minutes.

*Here's the furnace with lid during firing:*

In addition I made a new, smaller and much safer crucible by chopping off the bottom of a disused "SodaStream" (remember those?) carbon dioxide canister. It has a capacity of 50 ml, an inner diameter of 45 mm, a wall thickness of 3 mm and weighs about 190 g (see pic below). This should last a few firings, unlike the "soup can crucibles"!

I first got a bit of practice by empty firing the new crucible, lifting it out periodically and adding fuel when needed. Not a big problem, just rather finicky due to the small size of the furnace cavity.

Next I tried a 30 g charge of clean aluminium. That melted quickly in about 10 - 15 minutes of firing. Passivation was still a problem though: I didn't flux that time. I got the melt out with the usual difficulty caused by the aluminium oxide "skin" and was left with a crucible full of dross! So I returned it to the furnace and added quite a bit of LoSo salt (a 50/50 mixture of sodium and potassium chloride, NaCl/KCl). That melted almost instantly into a very mobile liquid and on adding more it just sank and melted away immediately. I cast it (it splatters a lot!) and ended up with quite a clean crucible.

The Perlite/fire cement refractory material held up well but did sustain a little fire-damage at the top: the exhaust flow is awesome at the estimated 5 - 6 kW power output. Due to the heat generated, the modest incoming cold air flow is isobarically expanded by a factor of almost 4!

Another melt (see pic below) of 32.6 g mixed aluminium (some clean and some scraps) with 16.3 g of LoSo added melted in about the same time,

with the fused salt mix clearly floating on top of the aluminium melt. Adding more pieces of scarp aluminium and forcing them in the melt with a dipping tool caused these to fuse immediately into the melt, as ice chips do in hot water. Here's that melt, the black LoSo flux floating neatly on top:

Then I had a little mishap: a fairly large cold blob of melted flux (LoSo) had stuck to the dipping tool and when I stirred the mix one last time the cold salt dropped in, cooling the melt considerably. The resulting cast was small but clean, with a lot of "cold" salt and metal left behind in the crucible. Elbow grease for cleaning that one up! Lesson: allow molten LoSo to rejoin the melt from the dipping tool and remove any cold LoSo prior to using it again...

So, I'm pretty sure I've boosted the temperature by quite a bit but still didn't know by how much...

Next I fired up again to try and melt a small (7.5 g) piece of what I believe to be "yellow brass". It was once part of the "SodaStream" dispensing valve. I've no idea of the composition of this alloy but I'm fairly sure that it's brass: yellow coloured and non-magnetic. I fired it for about 40 minutes and it didn't put a dent in it! That the alloy contained copper was clear: part of it coloured a bright red, probably from cuprous oxide formation.

**Conclusions so far...**

The improved furnace probably does fire at slightly higher temperature, judging by speed of reaching aluminium melting point and easy of melting salt. The molten salt was very mobile while before it was rather gooey.

The single brass melting test may not have been very conclusive but it seems likely only about 850 C (1560 F) has been reached and not the 900 - 950 C (1650 - 1740 F). This could be problematic for reaching the final goal of the project: to *fuse together copper and tin from copper oxide and tin oxide-carbon reductions*. I'm not even sure what temperature is needed to get these reactions going but I bet I'm a little borderline right now.

So, another attempt at improving the furnace will be made soon. I will fill the paint can to the rim (thereby gaining another 5 mm in height) and make the surface of the top of the furnace completely smooth so that the

smooth moulded lid leaves less daylight and "seals" the furnace better.

Another improvement can be made by better controlling the size of the charcoal. Due to the small size of the furnace, I need to break up the BBQ briquettes. I should take more care in getting about 1 $cm^3$ sized pieces and sift off the fines, to pack the furnace with a maximum fuel punch...

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**Update:**

Following a tip at this forum thread, I decided to play around with the airflow a little. I had previously reduced the airflow a lot and believed it to be more or less optimal. But the furnace was spewing out rather massive amounts of very hot air, definitely increasing the heat loss of the furnace. As all furnaces are essentially "heat pumps", to reach the highest temperature possible you need not only to generate as much heat as possible but also to retain as much of it as is achievable.

And so I ran a quick test to see if reduced airflow could increase furnace temperature. It would appear to be the case: with the reduced airflow the furnace melted a standard aluminium/LoSo charge in record time.

Then I attempted to melt that dastardly piece of "unknown brass" again, this time using some molten LoSo as heat transfer agent. *Again, no joy!*

Getting the balance between the amount of charcoal and the amount of air right is the crucial part here... that much I have learnt. More charcoal will only generate *more heat if it has enough oxygen*. But *too much air means you're blowing heat out of the furnace*. It's probably a more "delicate" balance for a smaller furnace.

Another poster at said forum suggested boosting heat output by squirting lighter fluid (in my case methanol) directly into the truyère, making it act as a carburettor. I'll try that but it does kind of corrupt the purpose of a "charcoal fired furnace".

Now the race is on to make the above mentioned improvements and work more on the balance between charcoal and air...

**The next instalment of this story can be found here.**

posted by Gert @ 1:40 PM 11 comments

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WEDNESDAY, JUNE 06, 2007

## A Coffee Can Foundry... (making bronze, part 4)

*This is Part 4 of my mini-saga on attempting to make home-made bronze, using a method similar to Bronze Age technology. Parts 1, 2 and 3 can be found here:*

Part 1: Goal, building and initial tests

Part 2: First attempts at metal melting

Part 3: Improving the foundry

**Lump charcoal is as lump charcoal does...**

As the refractory material (Perlite/fire cement composite) had started to suffer fire damage and the inner lining was losing mechanical integrity, I decided to increase the capacity a little by removing the degraded material (a strange pink salmon type of colour). The diameter of the furnace cavity is now about a 1/2 inch wider and slightly tapered. Next I moulded another 1/4 inch on the top, making it level with the rim of the paint can and moulded a new lid.

The foundry enthusiasts at the ABYMC forum made some more suggestions, from better regulating the airflow, using a hydrocarbon side feed to reverting back from briquette charcoal to the more expensive but hotter burning lump charcoal.

So I bought some new lump charcoal and fired her up, using the smaller pieces of charcoal only. It became immediately apparent that the furnace *burnt considerably hotter than previously*. It glows a nice bright orange, as does the crucible which previously yielded only a dull, dark red, only visible in fainter light.

*Here's the furnace with lid during firing:*

*In the cavity:*

The photo's colour is deceptive due to the temperature (the glow is a nice bright orange but not yellow).

A quick test with some 50 g of aluminium (some clean and some painted can scraps) led to melting in a matter of minutes. The resulting blob of clean aluminium shrank a lot because it was way over its melting point when poured.

Then the next litmus test: a 7.5 g piece of engineering brass of unknown composition, with some LoSo flux to improve heat transfer. It melted in about 5 minutes, indicating the required 900 - 950 C (1650 - 1740 F) had been reached comfortably!

One more run with three 2 pence coins (no LoSo) resulted in the coins being sintered together but not melted. Left the splatter of brass and right the three unfortunate 2p copper coins (heavily oxidised to cuprous oxide, I imagine).

I played around a little with the airflow but it didn't seem to make much difference. I'm probably getting close to optimum airflow. *The lump charcoal has the added advantage of producing much less ash, as the briquettes are formulated to generate ash for cooking.*

I'll try and further boost the heat with slightly finer coals but for now there's no need to inject hydrocarbons (propane or butane) into the tuyère. I will try that at a later date in an attempt to push the furnace to its thermal limit.

So, although the temperature isn't yet at the melting point of copper (1084 C, 1984 F), I feel confident that the achieved temperature is *sufficient to*

*glow tin and copper from their oxides using charcoal as a reducing agent.*

My tin oxide is about to be delivered and hopefully my own bronze age will then commence...

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**Update:**

I've just "*gone copper*"! Selecting the smaller lumps of charcoal and breaking up some bigger ones, I melted about 22 g of the same "yellow brass" in minutes. It caught fire and there isn't much left of it.
Carrying on, I tried the three copper 2 pence coins again and they too melted in a few minutes: so *I've got 1084 C (1984 F)!*

*Left what's left of the brass, right the blob of molten copper (both splattered onto dry sand):*

In fact the oven ran so hot that *the crucible softened noticeably* (it's got a small dent to prove it) because it yielded to my pliers.

*Hot, hot, hot!*

The whole run was approx. 40 mins and burnt 450 g of charcoal, putting the power output at approx. *6.2 kW (6,200 W).*

**The next instalment of this project can be found here.**

posted by Gert @ 10:17 AM

10 comments

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